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Electrical control and quantum chaos with a high-spin nucleus in silicon

Nuclear spins are the most coherent quantum systems in the solid state.
However, scalably controlling individual nuclei via magnetic resonance faces the challenge of confining magnetic fields at the nanometer scale.
Here we demonstrate the coherent quantum control of a single antimony (spin-7/2) nucleus, using localized electric fields produced within a silicon nanoelectronic device [1].
The method exploits a microscopic modulation of the nuclear electric quadrupole interaction and the presence of lattice strain, as revealed by a quantitative theoretical model.
The spin coherence time surpasses by orders of magnitude those obtained via methods that require a coupled electron spin for electrical drive.
This coherently-controllable antimony nucleus can be used to probe the foundations of quantum physics.
For instance, its dynamics accurately maps to a classically chaotic one: the driven nonlinear top.
Therefore, we can engineer a highly controllable, individual quantum system that enables an experimental study of the emergence of chaos and the quantum-to-classical crossover [2].

[1] S. Asaad, et. al, "Coherent electrical control of a single high-spin nucleus in silicon." arXiv:1906.01086
[2] V. Mourik, et. al, "Exploring quantum chaos with a single nuclear spin." Phys. Rev. E 98(4), 042206